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(56) Documents cited
GB 2037634 A GB 1580244 A GB 1575466 A
GB 1400338 A GB 1047606 A EP 0120584 A1
US 4836433 A US 4510987 A

(58) Field of search
UK CL (Edition L) B3F FCP FCXA FEX FGT, C7D DCA
INT CL[5] B22D
Online databases: WPI, CLAIMS

(54) Generating a slurry by shearing teemed molten metal

(57) A metal slurry is generated from a liquid metal being teemed by applying a high rotary shear rate in the region of a solidification front thereof. The metal is teemed through an annular apparatus and either the inner or outer wall of the annulus can be cooled and rotated. In Fig. 1 the slurry generator has a static core 2 surrounded by a rotating outer drum 3 with the liquid metal flowing through the annular space 11 therebetween. The outer drum is rotated at a speed so as to create a shear rate of greater than 5N/m² at the liquid front. The creation of a high shear stress and shear rate in the liquid metal adjacent the solidification front of the metal contributes to the formation of a slurry by promoting the formation of dendretic solids in the liquid metal and by increasing the rate of heat flow out of the metal.

FIG. 1.

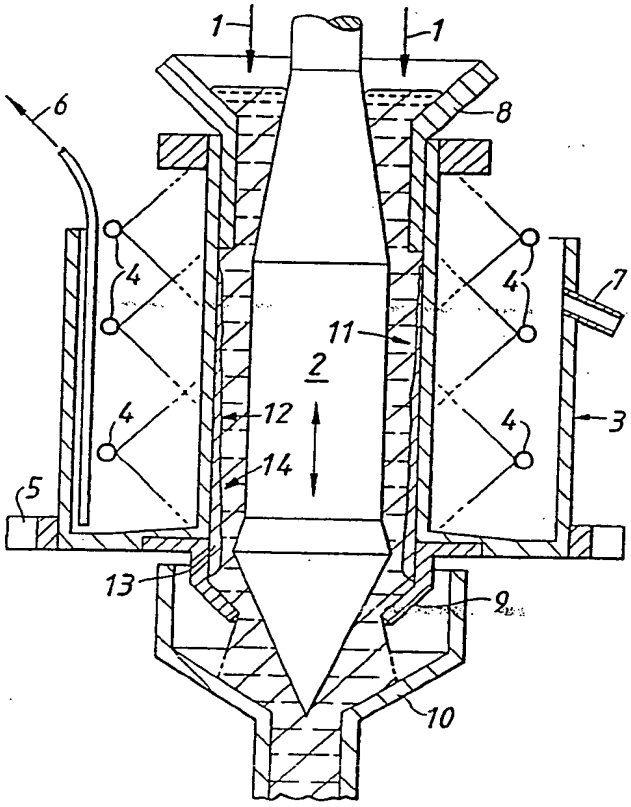

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FIG. 1.

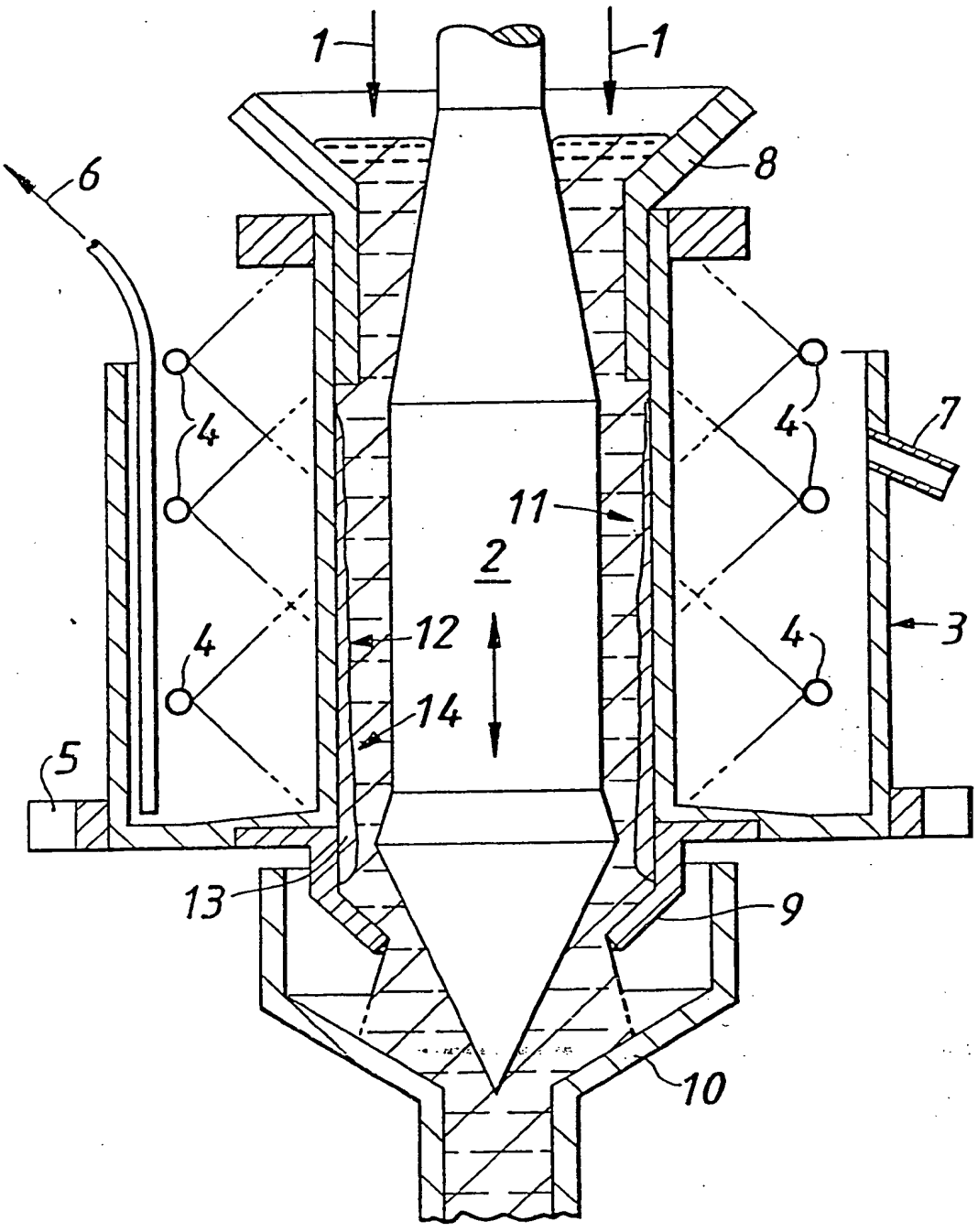
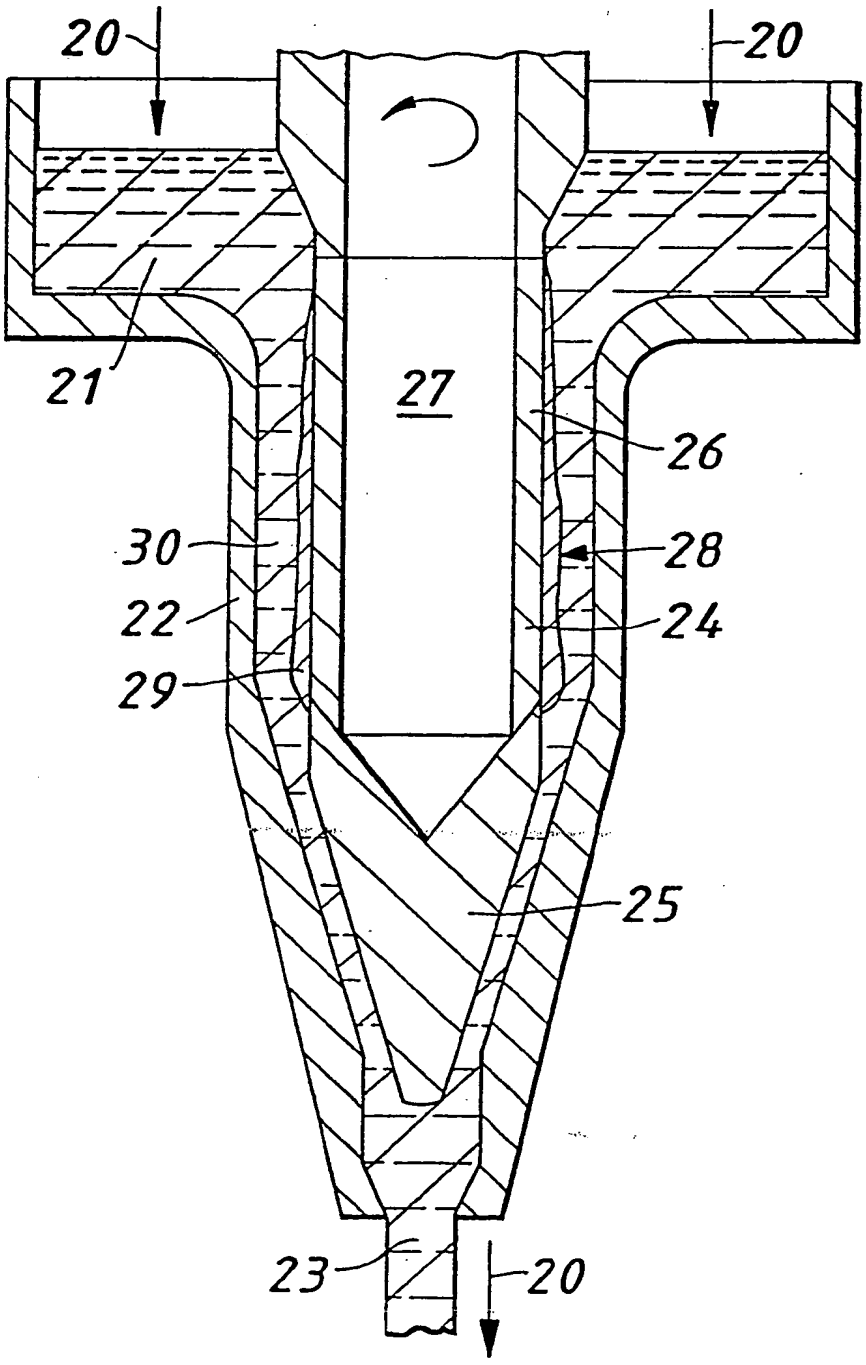


FIG. 2.



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LIQUID METAL PROCESSING

This invention relates to a method of processing liquid metal, and in particular to the production of a slurry of solids in the parent liquid metal. In casting liquid metal it is well established that casting a slurry has advantages in that the casting or soldification structure is more homogeneous. Various methods of heat extraction from the liquid metal to create a slurry as it is teemed into the mould have been suggested, and it is an object of the present invention to increase the heat that may be removed from a liquid metal as it is teemed thereby as well as mechanically promoting the creation of a slurry.

According to a first object of the present invention there is provided a method of generating a slurry from a liquid metal being teemed wherein a high rotary shear rate is applied to the metal in the region of the solidification front. The solidification front may be generated as a result of the cooling of the metal as it is teemed. The metal may be teemed through an annular passage way and the high shear rate may be applied by the rotation of the inner or outer wall of the annulus. The solidification front may be generated by cooling the wall of the annulus that is rotated. The shear rate preferably exceeds 5 N/m^2, and the high shear rate may be operative to promote the creation of dendritic material in the solidification zone.

The invention will now be described by way of example and with reference to the accompanying drawings of which Figures 1 and 2

show alternative forms of slurry generator. Turning now to Figure 1, a stream of liquid metal passes in the direction shown by the arrows 1 under gravity. It flows through an annular slurry generator which is shown in the figure in section. The slurry generator has a static core 2 and is surrounded by a rotating outer drum 3. Non-rotating water sprays 4 cool the wall of the drum adjacent the liquid metal and the drum is rotated by rotation gear 5. Drainage 6 and an overflow 7 are also provided and the drum is protected at the top where the hot metal initially enters it by a refractory liner and funnel 8. The drum has a refractory exit nozzle 9 and the slurry exits through a stream collector 10.

The operation of the slurry generator is straightforward. The liquid metal flows through the annular space 11 between the static core and the outer drum, and is cooled by its contact with the outer drum; the solidification front thereby generated is shown at 12 near the outer drum wall where the solidified shell 13 meets the liquid 14. The outer drum is rotated continuously or reciprocated in a rotary manner and the speed of rotation of the outer drum is arranged so as to create a shear rate of greater than $5N/m^2$, at this front. Because the outer drum is cooled as well as being rotated the highest shear rate (which is adjacent the rotating element) is also the region of the solidification front.

This arrangement of a rotating cooled shell to the annular apparatus is effective in three separate ways to increase the formation of a metallic slurry.

In the first place the formation of dendritic particles is increased by high shear stresses, and it is believed from experimental work that a shear stress of greater than $5N/m^2$ is preferable for the formation of such dendritic debris. This debris being solid particles suspended in the liquid directly mechanically contributes to the formation of the slurry.

In the second place, a high shear rate is known to improve the heat flow through the region. The rate of heat removal is thus maximised in the region of the solidification front, and thus the heat is conducted more efficiently to the cool surface.

Experimental results are given in Transactions ISIJ, Vol 28, 1988, pp 939-944, by Kobayashi et al. Figures 5 and 7 of that paper are particularly relevant.

Finally, it is believed that a high shear rate and thus a high rate of heat transfer contributes to the minimising of what is called the skull. The skull is the solidified metal which accumulates on cooler surfaces in metallurgical apparatus. This smaller skull in itself helps the transfer of heat by ensuring that the liquid metal is near to the cooled surface than would otherwise be.

Turning now to Figure 2 the inner, not outer, part of the annulus is rotated (continuously or reciprocated) and cooled. Thus the maximum shear stress is again applied to the liquid metal in the region of the solidification front. In Figure 2 the melt flows in the direction shown by the arrows 20 into a melt reservoir 21

and through a formed of an insulating refractory 22 until it emerges at 23. The rotor on the inside of the annulus is a shell 24 which may be of the type generally known as a stopper rod, and has a wear and abrasion resistant stopper rod end 25. The main part of the stopper rod is formed of a high conductivity material 26 and at 27 is a cooling medium which is maintained cool by means not shown (for example internal water cooling chambers may be used internally). The solidification front 28 is shown between the solid material 29 and the liquid material 30.

The effect on the liquid metal is the same as described with reference to Figure 1. A high shear stress is formed adjacent to the cooled surface, thus to create dendritic debris, and sufficient cooling by increasing the heat transfer rate through the increase of this parameter with shear stress is achieved. Other methods may be employed to enhance the shear rate or relative solid/liquid velocities in the region of the solidification front such as profiling of the surfaces exposed to the metal, since the vertical flow rate of the metal also contributes to the shear rate.

CLAIMS

1. A method of generating a slurry from a liquid metal being teemed wherein a high rotary shear rate is applied to the metal in the region of a solidification front thereof.

2. A method as claimed in claim 1 in which the solidification front is generated by the cooling of the metal as it is teemed.

3. A method as claimed in any preceding claim in which the metal is teemed through an annular passage way and the shear rate is applied by the rotation of one wall of the annulus.

4. A method as claimed in any preceding claim in which the solidification is generated by the cooling of the rotating annular wall.

5. A method as claimed in any preceding claim in which the shear rate exceeds $5N/m^2$.

6. A method as claimed in any preceding claim in which the shear rate is operative to promote the creation of dendretic material in the region of the solidification front.

7. Apparatus for generating a slurry in a liquid metal being teemed therethrough comprising an annular passage way having a rotatable cooled wall in which the said wall is rotated to apply a shear rate exceeding $5N/m^2$.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

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Relevant Technical fields

(i) UK Cl (Edition L) B3F (FCP, FGT, FCXA, FEX); C7D (DCA)

(ii) Int Cl (Edition 5) B22D

Search Examiner
P G BEDDOE

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASES: WPI, CLAIMS

Date of Search
24 MARCH 1993

Documents considered relevant following a search in respect of claims 1-6

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2037634 A (INDUSTRY) See especially Claims 1, 5; page 3 lines 101-119; Figure 1	1, 2, 6
X	GB 1580244 A (MIT) See especially page 6 lines 34-39	1, 5, 6
X	GB 1575466 A (CREUSOT) See especially Claim 1; Figure 1	1
X	GB 1400338 A (LEYBOLD) See especially Claim 1; page 4 lines 43-104	1
X	GB 1047606 A (STRICO) See especially page 2 lines 9-67	1
X	EP 0120584 A1 (INDUSTRY) See especially Claim 1; Example 1	1, 2
X	US 4836433 A (INSUL) See especially column 2 line 17 - column 3 line 25; Figure 1	1
X	US 4510987 A (COLLOT) See especially column 4 line 46 - column 5 line 31; Claim 1	1

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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P: Document published on or after the declared priority date but before the filing date of the present application.

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